Acid Base 2

Gas interpretation of acid-base disturbances is difficult. There will be one on your shelf. You're guaranteed at least one on the Step 2 as well. Unfortunately, being able to appropriately interpret a blood gas doesn't always prove incredibly useful in actual practice. But being able to master acid base disturbances can lead to an impressive evaluation (and can impress all your friends since they won't be able to do it). But in reality, if this stuff just takes too long and you still don't get it, take the hit on the test and move on. Better to randomly guess and get it wrong than spend 15 minutes on a question you may not get right (thereby wasting precious minutes that could have been used on other questions). With that in mind, let's get started.

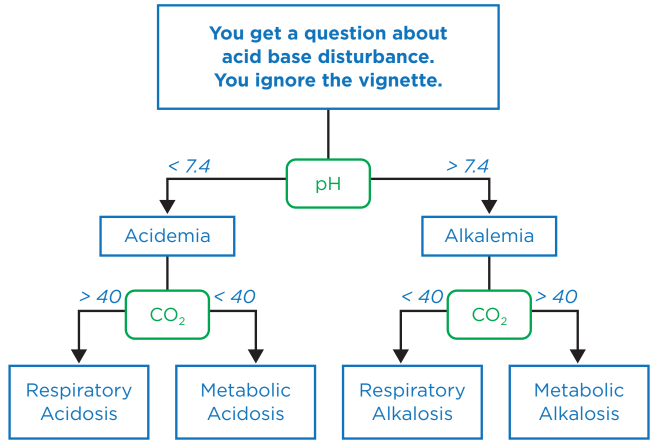

Figure 2.1

Follow the Steps

Step 1: Acidemia or Alkalemia. Use 7.4

- Is the pH < 7.4 (acidemia)
- Is the pH > 7.4 (alkalemia)

Step 2: Respiratory or Metabolic

See CO_2 as respiratory and acid. CO_2 is the respiratory acid. If you get rid of CO_2 you get rid of respiratory acid; this should create an alkalotic environment. If you retain CO_2 you hold onto more respiratory acid; it should create an acidotic environment.

After deciding if there's an acidemia or alkalemia ask, "What do I expect the CO_2 to be—high or low?"

If there's a pH < 7.4, expect the CO_2 to be higher than normal—that is > 40. If it is, the acidemia is caused by a respiratory acidosis. If it isn't, the acidemia is caused by a metabolic acidosis.

If there's a pH > 7.4, expect the CO_2 to be lower than normal (loss of respiratory acid). If it is, the alkalemia is caused by a respiratory alkalosis. If it isn't, the alkalemia is caused by a metabolic alkalosis.

This step is SUPER important because it decides what Step 3 is going to be. Once the primary disturbance is determined you then go through that disturbance start to finish.

Determining the Primary Disturbance

Step 1: Acidemia or Alkalemia

Step 2: Respiratory or Metabolic

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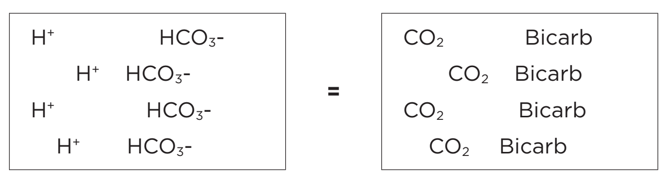
Step 3: is there something else wrong?



H^+	= "Respiratory Acid"	= pCO_2
HCO_3-	= "Metabolic Base"	= Bicarb
More H^+	= More pCO_2	= Low pH
Less H^+	= Less pCO_2	= High pH
More HCO_3-	= More Bicarb	= High pH
Less HCO_2-	= Less Bicarb	= Low pH

Step 3a: Check the Anion Gap

Always check the anion gap. It's normally 12. It's actually about 3 × albumin, normal albumin being 4, so this may change in real life. When handling acid-base problems, view them with the assumption of a normal anion gap = 12. The reason to always check the anion gap is because if present (regardless of other findings), there must also be an anion gap metabolic acidosis. That's true even if it isn't the primary disturbance.

Anion Gap = Na - Cl - Bicarb

Normal Anion Gap = 12 . . . or Albumin × 3

If the calculated anion gap (Na-Cl-Bicarb) is greater than the normal anion gap there is an anion gap metabolic acidosis

REGARDLESS of whatever else is going on

Respiratory Acidosis

Step 3b: Acute or Chronic

If the respiratory acidosis is acute then for every dime change (every 10 points) of CO_2 the pH should change by 0.08. If the respiratory acidosis is chronic, then for every dime change of CO_2 the pH should change by 0.04. Step 3b is to find out which it is: acute or chronic.

To do that, find out how many dimes from normal the CO_2 is. Multiply that by 0.08 and subtract from the normal pH of 7.4. Do it again multiplying by 0.04 and subtracting that from the normal pH of 7.4. Compare both scores to whatever the pH actually is. Whichever is closer determines the chronicity.

FOR EVERY "DIME" CHANGE IN CO_2			
Δ PH		Δ BICARB	
If Acute	0.08	If Acute	1
If Chronic	0.04	If Chronic	3

Table 2.1

Formula for memorizers:

7.4 - (Dimes × 0.08) = pH if acute
7.4 - (Dimes × 0.04) = pH if chronic

Pick the one closest to the actual pH

Step 3c: Is there a Metabolic Derangement

For respiratory acidosis the bicarbonate should change as well. For every dime change in CO_2 the bicarb should change by 1 point if acute or 3 points if chronic. Bicarb should change to compensate for the CO_2; in a respiratory acidosis the bicarb should go up.

Multiply the number of dime change of CO_2 by 1 (if acute) and by 3 (if chronic). Add that to a normal bicarb of 24. Compare to the bicarb you have. If there are more bicarbs than expected, there's also a metabolic alkalosis. If there are too few bicarbs, however, it's an additional metabolic acidosis.

Note that in the example the CO_2s don't change. When exploring Step3c the only care is the bicarb number (too few, enough, too many). The CO_2 doesn't matter except to the extent that we use it to determine how much the bicarb should have changed.

Formula for memorizers:

24 + (dimes × 1) = Expected bicarb if acute
24 + (dimes × 3) = Expected bicarb if chronic

If actual bicarb > expected bicarb: too many bicarbs = Metabolic Alkalosis

CO2 Bicarb
CO_2 Bicarb
CO_2 Bicarb
CO_2 Bicarb
Bicarb Bicarb

If actual bicarb < expected bicarb: not enough bicarbs = Metabolic Acidosis

CO_2 Bicarb
CO_2 Bicarb
CO_2 Bicarb
CO_2

Respiratory Alkalosis

It's literally the same for respiratory acidosis, except that the bicarb changes by 2 (if acute) or 4 (if chronic) for every dime change. Let's spell it out here.

FOR EVERY "DIME" CHANGE IN CO_2			
Δ PH		Δ BICARB	
If Acute	0.08	If Acute	2
If Chronic	0.04	If Chronic	4

Table 2.2

Step 3b: Acute or Chronic

If the respiratory alkalosis is acute then for every dime change (every 10 points) of CO_2 the pH should change by 0.08. If the respiratory alkalosis is chronic, then for every dime change of CO_2 the pH should change by 0.04. Step 3b is to find out which it is: acute or chronic.

To do that, find out how many dimes from normal the CO_2 is. Multiply that by 0.08 and add to the normal pH of 7.4. Do it again multiplying by 0.04 and adding that to the normal pH of 7.4. Compare both scores to whatever the pH actually is. Whichever is closer determines the chronicity.

Formula for memorizers:

$7.4 + (\text{Dimes} \times 0.08) = \text{pH if acute}$

$7.4 + (\text{Dimes} \times 0.04) = \text{pH if chronic}$

Pick the one closest to the actual pH

Step 3c: Is there a Metabolic Derangement as well?

For respiratory alkalosis the bicarbonate should change as well. For every dime change in CO_2 the bicarb should change by 2 point if acute or 4 points if chronic. Bicarb should change to compensate for the CO_2; in a respiratory alkalosis the bicarb should go down.

Multiply the number of dime change of CO_2 by 2 (if acute) and by 4 (if chronic). Subtract that from a normal bicarb of 24. Compare to the bicarb you have. If there are more bicarbs than expected, there's also a metabolic alkalosis. If there are too few bicarbs, however, it's an additional metabolic acidosis.

Formula for memorizers:

$24 - (\text{dimes} \times 2) = \text{Expected bicarb if acute}$

$24 - (\text{dimes} \times 4) = \text{Expected bicarb if chronic}$

If actual bicarb > expected bicarb:
too many bicarbs = Metabolic Alkalosis

CO_2 Bicarb
CO_2 Bicarb
CO_2 Bicarb
CO_2 Bicarb
Bicarb Bicarb

If actual bicarb < expected bicarb:
not enough bicarbs = Metabolic Acidosis

CO_2 Bicarb
CO_2 Bicarb
CO_2
CO_2

Metabolic Alkalosis

The only way this will happen is if the aldosterone is up. Don't care about the gas interpretation, but instead whether it's "salt sensitive," which always means, "volume responsive," which also asks, "are they volume deplete?" To figure that out simply give the patient volume.

The way Metabolic Alkalosis will appear on an acid-base interpretation question is as a secondary disturbance to a respiratory problem or on its own. That's it.

Metabolic Acidosis

Step 3a: Check the anion gap. See above.

Step 3b: is the CO_2 appropriate for this bicarb?

Assess if the pCO_2 on the ABG is appropriate for the bicarbonate. To do this, multiply the bicarb by 1.5 then add eight to that total. There is some fudge factor here. An acceptable range of pCO_2 is that number plus/minus 2.

If the pCO_2 is in that range then there's no respiratory disturbance.

If the pCO_2 is higher than that range, then there are too many respiratory acids, which means an additional respiratory acidosis.

If the pCO_2 is lower than that range, there are too few respiratory acids, which means an additional respiratory alkalosis.

Step 3c: is there another metabolic derangement?

You'll read about the delta-delta. Stop reading about the delta-delta. It's simple to calculate but requires memorization to interpret. So we use the add-back method instead.

A normal anion gap is 12. Take whatever the anion gap is right now and find out how many extra acids were needed to get there. Current Anion Gap - Normal Anion Gap. That number is the number of acids added to solution / the number of bicarbs that came out of solution. To find out how many bicarbs we started with before the anion gap business, add that number to the current bicarb.

That value is how many bicarbs we started off with. Normal is 24.

If there are too many bicarbs (>24) there are too many metabolic bases – there's an additional metabolic alkalosis.

If there are too few bicarbs (<24) there are too few metabolic bases – there's an additional non-gap metabolic acidosis. Because we started with an anion-gap acidosis, this must mean we have an additional non-gap metabolic acidosis.

The Expected CO_2 for Bicarb is Winters' Formula

Expected CO_2 = **Winters** = (Bicarb × 1.5) + 8 ± 2

Bicarb you have / constant / fudge factor

If actual CO_2 > expected CO_2:
too many CO_2s = Respiratory Acidosis

CO_2 Bicarb
CO_2 CO_2 Bicarb
CO_2 CO_2 Bicarb
CO_2 Bicarb

If actual CO_2 < expected CO_2:
not enough CO_2s = Respiratory Alkalosis

CO_2 Bicarb
CO_2 Bicarb
Bicarb
Bicarb

Add Back Method

Actual Anion Gap - Normal Anion Gap = Delta

Given to you / 12 (Alb x 3) / = Calculated

Then...

Delta + given bicarb = expected bicarb

If actual bicarb > expected bicarb:
too many bicarbs = Metabolic Alkalosis

CO_2 Bicarb
CO_2 Bicarb
CO_2 Bicarb
CO_2 bicarb
Bicarb bicarb

If actual bicarb < expected bicarb:
not enough bicarbs = Metabolic Acidosis

CO_2 Bicarb
CO_2 Bicarb
CO_2
CO_2